ON SOME POINTS IN THE EARLY HISTORY OF ASTRONOMY.[1]

V.

IT is imperative to be perfectly definite and clear on the question of the amplitudes above 26° at Thebes. Any amplitude within 26° means that up to that point the sun at sunrise or sunset could be observed some day or days of the year—once only in the year if the amplitude is exactly at the maximum, twice if the maximum is not reached. But in the case of these temples with greater amplitudes than 26°, it is quite clear that they can have had nothing to do with the sun. Is there, then, any additional line of evidence that the Egyptians used these temples to observe the stars? Here a very interesting question comes in; a temple built at one period to observe a star could not go on for ever serving its purpose, for the reason that the declination of the star must change by precession. Therefore a temple built with a particular amplitude to observe a particular star, useful for one period would be useless for another.

We have here possibly a means of testing whether or not any of these temples were used to observe the stars. In those very early days, 3000 or 4000 years B.C., we must assume that the people who observed the stars had not the slightest idea of these possible precessional changes; they imagined, that they were just as safe in directing a temple to a star as they were in directing a temple to the sun But with a star changing its declination in an average way, the *same* temple could not be used to observe the same star for more than 200 or 300 years; so that at the end of that time, if they still wished to observe that particular star, they must either change the axis of the old temple, or build a new one.

As a matter of fact, we find that the axes of the temples have been changed and have been freely changed; that there has been a great deal of work done on many of these temples which are not oriented to the sun, in order to give them a twist.

Once a solar temple a solar temple for thousands of years; once a star temple only *that* star temple for something like 300 years, so that the conditions were entirely changed.

We get cases in which the axis of a temple has had its direction changed, and others in which, where it has been difficult or impossible to make the change in a temple, the change of amplitude has been met by putting up a new temple altogether. We are justified in considering such temples as a series in which instead of changing the orientation of a pre-existing temple, a new temple has been built to meet the new condition of things. That, I think, is a suggestion which we are justified in making to Egyptologists on astronomical grounds.

We cannot, of course, make it with absolute certainty, for the reason that in the case of most of these temples the best Egyptologists cannot give us the most precious piece of information which we require from the astronomical point of view. That is the date of the *foundation* of the temple. If in the case of these temples it were absolutely certain that each temple was built at a certain time with a certain orientation, the use of the precessional globe would tell us at once whether or not that temple was pointed to any particular star. Some other astronomical considerations may here come to our help. If the north polar distance of a star is increasing—that is, if it is increasing its distance from the north pole—its declination is being reduced, and the orientation of the temple would be gradually becoming more and more parallel to the equator; if the declination of the star be increasing, then the orientation of the temple would have had to be more and more north or south. The change in the orientation, therefore, could give us important information, and ultimately we might be able to determine what the name of that particular star was. At present the matter must remain more or less as a suggestion; but if anything like approximate dates can be given, then astronomy really may come to the rescue of the Egyptologist and archæologist generally, and repay that debt to which I have referred, which she owes to so many other sciences.

Although, however, these matters can be discussed in a way that will indicate that the inquiry is raised, I do not wish for one moment to speak of it as being settled, because the observations which have been made already in Egypt with regard to the orientation of these temples have not been made from such a very special point of view; and further some alteration in the amplitude would be made by the presence of even a low range of hills miles away from Thebes in the case of a star rising or setting pretty nearly north or south. No one would care to make the assertion with absolute definiteness until it was known whether or not the horizon in each case was interfered with by hills or any intervening objects—was or was not one, in fact, which might be regarded as a sea horizon from the point of observation; if there were impediments, the angular height of them must, of course, be exactly known.

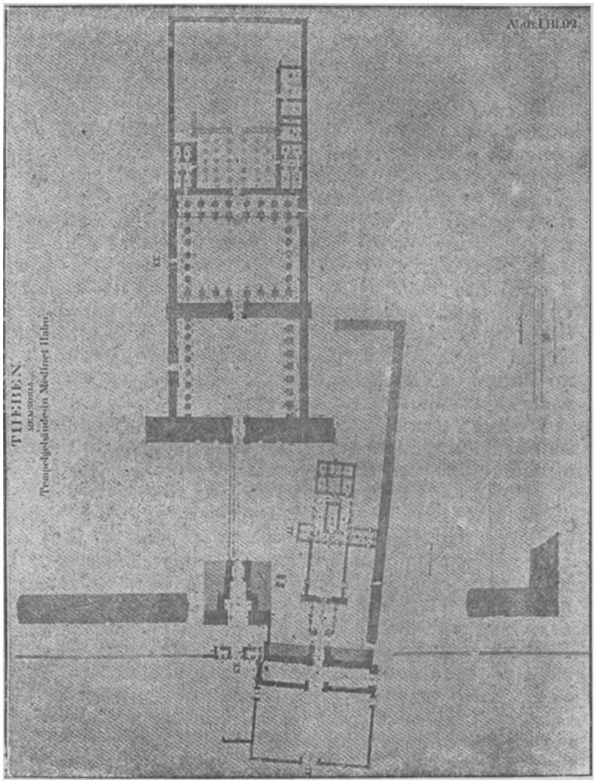

FIG. 14.—The two temples at Medinet Abou, showing the change in their orientation.

To continue this observation and this kind of thought a little further, we will go back to Karnak generally. In the first place we have the magnificent solar temple.

Next we have two parallel temples, one of them a late addition to the solar temple itself, and another one parallel to it, each of them with an amplitude of 63°, one N. of E., the other S. of W. We have then two parallel temples *at right angles* to the solar temple at Karnak. We have also a temple, with an azimuth of 68° N. of E., and one, probably older still, with an amplitude of 70° or 71° N. of E.; both these temples face northerly, and nearly in the same direction. Near the last temple we have the ruins of another one at right angles to it, and this points to the westward amplitude 19° N. of W. We may assume from the plan of the ruins that the Naos is at the east end of the temple, therefore the chief pylon would have been to the west, and therefore the axis will be in that direction. In the row of sphinxes, a double row connecting the temples of Maut and Karnak, the line is absolutely complete as far as their bases are concerned, with the exception of two where there is a gap, and that gap is exactly in the axis of this temple prolonged. Here is another instance of the rights of the line of sight of a temple being strictly preserved.

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[1] Continued from p. 110.

The Egyptians have been accused of hating every regular figure, and even in the boundary walls of the temple of Ammon there are two obtuse angles. Round the Maut temple we also have walls, and there again this hatred of similarity seems to come out, for we have one obtuse and one acute angle. But if we examine the thing a little carefully, we find that there is a good deal of method in this apparent irregularity. The wall of the temple of Ammon is parallel to the face of the temple or at right angles to its length. One wall of Maut is perfectly parallel to the face of the temple or at right angles to the sphinxes. And the reason that we do not get right angles at one end of the wall is that the walls of the temple at Maut are parallel to the chief wall of the temple of Ammon. Surely it must be that, before these walls were built, it was understood that there was a combined worship, that they stood or fell together. One thing was not attempted in one temple and another thing in another, but the worship of each was reflected in the other. And if this be true you see that there was no hatred of symmetry, but a definite reason why these walls should be built as they were.

We can depend, and no doubt depend very completely indeed upon the labours of the Egyptologists, in the case of the temples of Rameses and of Khons. No Egyptologist so far, I believe, has ventured to tell us the date of the foundation of Karnak, but what Egyptologists have stated is that those two temples were built by the same king; their architecture is exactly similar, they are parallel to each other, and they altogether bear reference to apparently the same period of Egyptian history. Now that king was Rameses III., and the year according to Brugsch was 1200 B.C. Here then we have a definite basis of work. There is a temple with an amplitude of 63° N. of E., built 1200 B.C.; there is a temple with an amplitude of 63° S. of W., built 1200 B.C. From these amplitudes we determine as before the declinations; they come out 53° N. and 53° S.

Was there an important star with a declination of 53° N., was there another with a declination of 53° S. in the year 1200 B.C.? There *were* two important stars, one with a declination of 53° N. and another of 53° S. at that time. The north star was γ Draconis, the south star was Canopus. This strengthens the view that there was really some astronomical object in the plan and direction of these temples.

Thus, at the time when these two temples were stated to have been built, each *might have been used* to observe one the rising, the other the setting, of an important star. We have long ago seen that so far the Egyptians, like the Babylonians at a later date, only had an idea of observing a heavenly body and the position of other bodies in relation to it, so long as it was rising or setting, so that it was absolutely essential that the body which they were to observe should rise and set. You know perfectly well that in London there are many stars which neither rise nor set. The latitude of London being 51°, the elevation of the pole therefore is 51°, and from the pole to the north point of the horizon being 51°: of course any star which lies at that distance from the pole cannot set, but sweeps round without touching the horizon at all. The latitude of Thebes being 25°, the distance from the pole to the horizon is much smaller, and so the number of stars which do not rise and set is much smaller. The stars which did not rise or set were stars which were moving very slowly and the stars which rose most to the north and most to the south were those bodies which were moving most slowly while they yet rose or set. Can this slow rate of motion have had anything to do with such stars being selected for observation, the brightest star to the north, most slowly moving, the brightest star to the south most slowly moving? It is possible that observations of these stars might have been made in such a way that at the beginning of the evening the particular position of γ Draconis might have been noted with regard to the pole star, if there were no other reason; and seeing that the Egyptians thoroughly knew the length of the night and of the day in the different portions of the year, they could at once the moment they got the starting point of the rising of this star practically use the circle of the stars round the north pole as the dial of a sort of celestial clock. May not this really have been the clock with which they have been credited? However long or short the day, the star which was at first above the pole star, after it had got round so that it was on a level with it, would have gone through a quarter of its revolution.

So much then for the possible use of the temples built by Rameses III. in the year 1200 B.C. It has already been pointed out that although we have in one an amplitude of 63° N. of E. we have other temples with amplitudes of 68° N. of E. and 71° N. of E. Everybody agrees that the temple, with amplitude 63° N. of E., was built 1200 years B.C. I have shown that that temple could have observed the most northerly star which did not set. May it not have been that the 68° temple and the 71° temple were temples built to observe the same star *before* this one was built, because we know they could not have observed the star *after* this one was built, since γ Draconis was decreasing its declination, therefore in previous times its declination would have been *higher*, and the amplitude therefore of a temple to observe it would have been greater.

Looking back to the German tables and other calculations, we find that with an amplitude of 68° we get a declination of 56°, and the same tables tell us that that declination was the declination of the same star γ Draconis 2000 years B.C. It does look as if in all probability we are dealing with a series of temples not twisted but built in different places.

Can we consider that the temple with an amplitude of 71° might have been used to observe that same star long before the temples were built with amplitudes of 68° and 63°? The amplitude of 71° gives us a declination of 58°, we then find the year in which that same star γ Draconis had that declination to have been about 3000 years B.C. So that it is not impossible that temple was built first of all to observe γ Draconis 3000 years B.C., that after a time the star changed its declination so much that another temple became necessary, and 1000 years afterwards the change again became large, and still another temple was built to observe it. The three temples may form one series.

The discussion is a little difficult because the orientation is very far towards the south and north, and therefore a hill a few miles off would make a difference of 2° or 3° in the orientation of the temple, and as yet we have no observations that throw light on this point.

We have then at Thebes alone three converging lines of evidence which all go to strengthen the view that these temples were really—whatever else they might have been—usable as solar and stellar observatories. The difference being of course that in the case of the solar temple no large change of amplitude was necessary, but that in the case of every stellar temple after a lapse of a certain number of years depending upon the position of the star, the temple must be twisted round if it were wished to continue to make observations of the same star.

That raises an interesting question by the way. Long after the temple had been used for observation of a particular star, long after that temple line was blocked by extended building, if the horizon of these temples was left open it looks very much as if when another bright star came along it was laid hold of for a new set of observations. However that may be, it is rendered extremely probable, by the considerations I have brought before you, that the Egyptians 3000 years B.C. had been rendered practically conversant with the result of the precession of the equinoxes by the fact that they had to rebuild and alter their temples from time to time because the stars changed their declination. If that be confirmed by subsequent investigations, it will show that these Egyptians possessed a very much more profound knowledge of astronomy than they have received credit for, because it is stated that the precession of the equinoxes was discovered by Hipparchus. It looks as if the precession of the equinoxes was probably published by Hipparchus as the result of an examination of the untold wealth of Egyptian astronomical observations which has been unfortunately lost to the world.

This question of orientation is after all one which survives among ourselves. All our churches are more or less oriented, which is a remnant of old sun worship, and the church is not always oriented exactly to the east, but so that the light of the sunrising upon the Saint's day to whom the church is dedicated may be thrown along the chancel.

It has long been known that Stonehenge is oriented to the rising of the sun at the summer solstice. Its amplitude instead of being 26° is 40°; with a latitude of 51°, the 26° azimuth of Thebes is represented by an azimuth of 40° at Stonehenge.

The first of January is very near the winter solstice, but is not quite the winter solstice. If you look up the old records of the races that lived 2000 or 3000 years B.C., you will find that the different races began their year at different times, and even that the same race at different times began their year differently; the choice lay among the equinoxes and the solstices, and seeing that one of the very oldest temples at Thebes is oriented to sunset at the summer solstice we should not be at all surprised if investigation shows that when that temple was built more than 3000 years B.C., the Egyptian year really began in what we should call our summer. We have ample evidence of this. And I think there is little doubt that when Stonehenge was built it certainly was built by people who began their year with the summer solstice, which you will remember is the time of the year in which in many countries it is the habit still to light fires upon hills and so on.

The next point is, what was probably the use made of these temples besides determining the length of the year and regulating so far as they could the seasonal changes, the times of the solstices, the times of the equinoxes, and the various celestial phenomena?

We understand that in the very beginning of observations in all countries, the moment man began to observe anything, we saw that he began to observe the stars, and the moment men began to talk about anything they had seen they must have started by in some way or other defining the particular stars they meant.

They would obviously talk first of the brightest stars, and separate them from the dimmest ones; they would then discuss the stars which never set, and separate them from those which did rise and set; then they would take the most striking configurations, whether large or small; they would choose out the constellation of Orion or the Great Bear, and for small groups the Pleiades. These would attract attention, and be named before anything else. Then later on it would be imperative in order to connect their solar with their stellar observations that they should name the stars which lay along the sun's path in the heavens. They would confine their attention to a belt round the equator rather than consider the configuration of stars half-way between the equator and north pole. In all countries—India, China, Babylonia, Chaldæa, Egypt—they had a sort of girdle round the heavens, called by different names in different countries, and the use of this girdle of stars, which sometimes consisted of twenty-eight stations, sometimes of twenty-seven, and sometimes of only ten, was to enable them to define the place of the moon or of any of the planets in relation to any of these stars. That condition of things, that stage of thought, is brought well before us in the Jewish Scriptures.

In the Book of Job we read, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion? Canst thou bring forth Mazzaroth in his season? or canst thou guide Arcturus with his sons?"

Here we have the difficulty which has met everybody in going back into these old records, because there was no absolute necessity for a common language at the time; it was open to everyone to call the stars any name they chose in any country, therefore it is difficult for scholars to find out what particular stars or constellations were meant by any particular words. In the revised version, Arcturus has given place to the Bear with its train, and even our most distinguished scholars do not know what Mazzaroth means. I wrote to Prof. Robertson Smith the other day to ask him to give us the benefit of his great knowledge, and he says that Mazzaroth is probably that band of stars round the ecliptic or round the equator to which I have referred, but he will only commit himself to the statement that it is a probable enough conjecture; other people believe that it was a reference to the Milky Way.

I mention this to show you how very difficult this inquiry really is. The "seven stars" undoubtedly mean the Pleiades and not the Great Bear. Among the brighter stars, Arcturus, the Pleiades, &c., are referred to by Homer and still earlier writers. So far as Egyptian and Chinese astronomy goes, practically the first reference to a constellation appears in Egypt with reference to the equinox which happened 3285 years B.C., and in China with reference to the Pleiades in the equinox of 2357 B.C.

In observing stars nowadays, we use a transit circle which is carried round by the earth so as to pick up the stars in different circles round the axis of the earth prolonged, and by altering the inclination of the telescope of this instrument we can first get a circle of one declination and then a circle of another.

The Egyptians did not usually employ meridian observations. Did the Egyptians make star maps? They certainly did. In the temple of Denderah, which is a comparatively modern temple, there is a very precious series of records which is certainly not at all modern. It represents a good many of the Egyptian constellations. The central part was in all probability the zenith point of Denderah itself, and at a certain distance from the centre point we have the zodiac represented excentrically. The constellations round the edge are those nearest the horizon; the central ones are those nearest the north pole; instead of having the Great Bear, we have the constellation of the Thigh, representing the well-known seven stars; in addition we have the constellation Hippopotamus, which has now entirely disappeared. There is also a Babylonian zodiac, which will show you that, although Babylonia and Egypt were adjacent countries, yet that they had a perfectly different set of constellations. Our present constellations came not from Egyptian times, but from much later—from Greek times. It is almost impossible to hope to recover the names of the constellations used by people earlier than the Greeks, but still much is to be hoped from the study of the Babylonian records. In these we have a snail being drawn along by the tail of a snake or dragon. It is quite possible that we may have there the origin of our constellation Draco, which is the northern constellation, and it is quite possible that this snail may indicate that the stars in it moved with very great slowness. But it is impossible at present to co-ordinate these different fancies together.

A very important paper has recently been published by Mr. Le Page Renouf suggesting that before the year 1500 B.C. the Egyptians really had an idea of meridional observations. These observations are recorded in several manuscripts found in tombs; they seem to have been given as a sort of charm to the people who were buried in order to enable them to get through the difficulties of the way in the nether world.

The hieroglyphs state that a particular star of a particular Egyptian constellation is seen at a particular hour of the night; we have twelve lines representing the twelve hours of the night, and it is stated that we have in these vertical lines the equivalent of the lines in our transit instruments, and that the reference "in the middle," "over the right eye," "over the right shoulder," or "over the left ear," as the case may be, is simply a reference to the position of the star.

If this should be confirmed, one of the remarkable things about the inquiry will be that the Egyptians did not hesitate to make a constellation cover very nearly 90°. In those days evidently they wished to have as few constellations including as many stars as possible, in order perhaps that things might be more easily remembered.

When the zodiac of Denderah was mentioned, I pointed out the constellation of the Hippopotamus very near the north pole. This constellation is referred to in the records in question.

Such then are some of the ideas which are suggested by the recent work of the Egyptologists. You see, I trust, that it is important that this work should be continued as closely associated as possible with astronomical ideas, because, merely taking a very small part of the area of which they have begun the consideration, we have come to the conclusion that, dealing with the temples alone, there seems a very high probability that 3000, and possibly 4000 B.C. the Egyptians had among them men with some knowledge of astronomy, and that 6000 years ago the course of the sun through the year was practically very well known, and methods had been invented by means of which it might in time be better known, and that not very long after that they not only considered questions relating to the sun, but began to take up other questions relating to the positions and the movements of the stars. It is quite probable that 1500 years B.C. at least they had an idea of meridional observations. If this be so, and if more and more can be proved, I think you will agree that, as I said before, astronomy will have a slight opportunity of repaying some of the great debt which she owes to the other sciences.

J. Norman Lockyer.

THE LATER LARVAL DEVELOPMENT OF AMPHIOXUS.

THE memoir by Mr. Arthur Willey, B.Sc., of University College, London, on this subject, in the *Quart. Journ. Microsc. Science*, March 1891, deserves more than a passing notice. It is one of the most important contributions which have been made to a knowledge of this very interesting animal. In the summer of 1889, Mr. Willey was sent by Prof. Ray Lankester with the aid of a Government grant to collect the larvæ and embryos of Amphioxus at Faro, near Messina. He returned with a large series, and in the winter 1889-90 worked out in the laboratory of University College, chiefly by means of sections, the history of the formation of the atrial cavity in this animal. In a paper published jointly by Prof. Lankester and Mr. Willey (*Quart. Journ. Micr. Sci.*, August 1890), it was shown that the atrial cavity does not form, as supposed by Kowalewsky and by Rolph, as the result of a down-growth of lateral epipleura; but that it forms as a longitudinal groove which sinks inwards along the ventral surface, becoming floored in by a small horizontal growth on each side corresponding merely to that portion of the adult animal's ventral surface which lies between the two metapleura. The groove, now become a narrow tube, expands right and left, until it acquires the proportions of the adult atrial chamber.

The preserved material brought home by Mr. Willey in 1889 did not enable the observers to determine the mode of origin of the second row of gill-slits. Stages were noted in which there were as many as fourteen gill-slits of the first series (which are placed anteriorly on the animal's right side), and stages were observed, of no greater size, in which two rows of gill-slits were present—one series on the right side and one on the left side of the pharynx; whilst the mouth, which in the specimens with a single series was completely lateral (on the left side), had now taken up a median position.

Mr. Willey again visited Faro in the summer of 1890, for the purpose of determining, by the study of living transparent larvæ, exactly the mode of origin of the second row of slits, and the steps in the "symmetrization" of the larva. The brief account and few unconvincing figures given by Kowalewsky, in 1866, in relation to this matter had not commanded general confidence, although it was felt that so accurate and accomplished an observer could not have been completely mistaken. Balfour had said, in reference to Kowalewsky's observations on this matter, that he was "tempted to suppose that his observations were made on pathological specimens."

Mr. Willey completely and most successfully accomplished the object which he set before himself in his second visit to Faro, and the results obtained are given in the paper under notice, illustrated by three folding-plates. He confirmed the main feature of Kowalewsky's observations, viz. that the first row of gill-slits, after having (so far as the first eight are concerned) taken up a position on the *right* side of the pharynx, rotate downwards across the median ventral line, and rise up into position on the *left* side, whilst, simultaneously, a new series appears on the right side, not one by one, but as many as six being formed at approximately the same moment. Mr. Willey corrects Kowalewsky's brief account in one or two numerical details, and adds some very important facts, which are quite new. He shows: (*a*) that the anteriormost slit of the primary series closes up and disappears during the process of rotation; (*b*) that some of the hinder slits of this series, which are not far advanced when the rotation begins (there being usually fourteen, of which the last six are very small, and lie in the median ventral line), also close up; so that, when the rotation is complete, and the second series of gill-slits has advanced in development to the number of eight, a "critical phase" is reached in which there are only *eight* gill-slits on each side of the pharynx, all fairly well developed. From this time forward new gill-slits are formed on each side behind the last formed, and continue to increase in number so long as growth continues, which appears to be as long as the Amphioxus lives.

But the most important discovery made by Mr. Willey is as to the origin of the endostyle, a structure which has great importance from the fact that it can be clearly identified, on account of its minute histological structure, with the endostyle of the Ascidians.

In the anterior region of the buccal cavity, previous observers have described in very young Amphioxus larvæ (with only one gill-slit) an elongated gland; "the club-